come very indistinct in the ultraviolet, sometimes completely disappearing at wavelengths below 3500 Å.

Syrtris Major is the same intensity as its surroundings in the blue, only becoming detectable at wavelengths longer than about 4500 Å, and remaining considerably darker than the rest of the disk out to a wavelength of at least 6000 Å.

The Elysium is visible on all scans for 17 April, being much brighter at wavelengths below 3500 Å and above 5000 Å than in the blue.

Most of these measurements of features are relative to the disk since only one night was of photometric quality; however, on that night calibrations were made by observing the standard star θ Virginis.

On the basis of their spectral distributions, the Martian blue haze and the white (or blue) clouds seem to be different manifestations of the same phenomenon. In addition, there is good indication that the Martian atmosphere is considerably more transparent at $\lambda 3400$ than at $\lambda 3700$.

This work was supported in part by NASA Grant NsG-451.

Spectrum Variations in the Wolf-Rayet Binary HD 211853. KATHERINE BRACHER, *University of Southern California*.—Spectrographic observations of the Wolf-Rayet double-lined spectroscopic and eclipsing binary HD 211853 were made at the Kitt Peak National Observatory in 1964 and 1966. Radial velocity measures indicate that the period should be modified slightly from that derived by Hjellming and Hiltner: the new value is 6.6881 days. The behavior of the variable absorption feature at 3870 Å has been investigated. If this is interpreted as a violet-displaced absorption of He I $\lambda 3889$ emission in the expanding shell of the W star, its average velocity is -1425 km/sec, somewhat larger than the expansion velocity of 1250 km/sec indicated by the width of the emission line He II $\lambda 4686$. The absorption feature is variable in intensity, being nearly absent on plates taken around phases 0.4 to 0.6, and increasing to a very prominent absorption line at phases 0.85 to 0.15, when the W star is in front. The line is also variable in radial velocity; however, the velocity variations seem to be in phase with the absorption lines of the B companion rather than with the W star. This raises doubts as to the identification of the line; this problem and the intensity variations with phase are discussed.

Solar Wind and Solar Rotation. JOHN C. BRANDT, *NASA/Goddard Space Flight Center*.—Braking of stellar rotation due to angular momentum loss in a stellar wind is an attractive, intrinsic mechanism

compatible with the observed rotations of main sequence stars; accurate determination for the solar case is essential as a calibration point. The azimuthal velocity w_t of the solar wind plasma near the orbit of earth was first assigned a value of 9 ± 3 km/sec from a study of the orientations of Type I comet tails by Brandt (*Astrophys. J.* **144**, 1221, 1966). Improvements in the analysis do not change this result. In addition, the results are supported by the fact that higher values of w_t are correlated with the higher values of the geomagnetic index K_p , as might be expected. Independent confirmation comes from studies with the Vela satellites by Strong, Asbridge, Bame, and Hundhausen (Conference: Zodiacal Light and Interplanetary Medium, Honolulu, February 1967), who find $w_t = 10 \pm 4$ km/sec.

Theoretical treatments by Weber and Davis (*Astrophys. J.* **147**, 217, 1967) and Modisette (*J. Geophys. Res.* 1967) indicate that part of the solar angular momentum is carried off in the magnetic stresses in the interplanetary magnetic field. The relative fractions are determined by the velocity structure of the solar wind near the sun; they are calculable from the observed azimuthal velocities and theoretical expressions. Typical parameters near the earth— $w_r = 400$ km/sec, $w_t = 9$ km/sec, $N_e = 4/\text{cm}^3$, and $B_r = 5\gamma$ —indicate that the solar angular momentum is lost nearly equally in particle motions and magnetic stresses and that the e -folding time for solar braking is $3\text{--}4 \times 10^9$ yr for a solar wind constant at its present value. If the solar wind has an independent e -folding time of 3×10^9 yr, the initial sun could have had an equatorial rotational velocity $\approx 10^3$ km/sec.

Radio Interferometry with a Baseline of 3074 km. N. W. BROTEN, T. H. LEGG, J. L. LOCKE, C. W. MCLEISH, R. S. RICHARDS, *National Research Council, Ottawa*, R. M. CHISHOLM, *Queen's University, Kingston, Ontario*, H. P. GUSH, J. L. YEN, *University of Toronto*, AND J. A. GALT, *Dominion Radio Astrophysical Observatory*.—Previous high-resolution measurements made at centimetric wavelengths with baselines of 100 km or so have indicated that some quasars have angular diameters of 0.025 sec of arc or less. Observations to this order of magnitude at metric wavelengths require very long baselines with subsequent problems in the transmission of data and local oscillator signals. Furthermore, it is difficult to compensate for the large and variable delay between reception of the signals at the two telescopes. These difficulties have been overcome by the use of wide-band magnetic tape recorders and independent local oscillators controlled by rubidium frequency standards.

Interferometric fringes have been observed from

3C273 and 3C345 at a frequency of 448 MHz ($67\text{ cm } \lambda$) with a baseline of 3074 km ($4.6 \times 10^6 \lambda$). These observations indicate that the diameter of these sources is less than 0.02 sec of arc at this frequency.

Observations at this frequency have also been made at a baseline of 183 km ($2.7 \times 10^5 \lambda$) and fringes have been observed from about a dozen sources.

Rotational Velocities of Southern B Stars.

WILLIAM BUSCOMBE, *Mount Stromlo Observatory*.—Direct-intensity tracings from coude spectrograms have been analyzed for about 60 B stars in the region from 3800 to 4900 Å. The original dispersion on the plates is $150\text{ } \mu/\text{Å}$ enlarged to $9\text{ mm}/\text{Å}$ for the profiles.

For each spectral class a group of from three to eight intrinsically sharp absorption lines has been selected, and rotational velocities determined from the width at half-intensity. In addition, equivalent widths have been measured for all the distinct lines.

From the observed profiles it is apparent that several sharp-lined stars near the main sequence have been incorrectly assigned to higher luminosity and temperature classes, on the basis of earlier surveys with spectrograms of lower dispersion.

Stellar Accretion and X-Ray Sources.

A. G. W. CAMERON, *Belfer Graduate School of Science*.—The process of rapid mass accretion onto compact stars has been studied, following Shklovsky's suggestion that such accretion onto a neutron star can be responsible for the features of the Scorpius x-ray source. It is found that in this case, most of the energy is emitted after the infall is halted, and the released gravitational potential energy is about evenly divided between thin-source bremsstrahlung at $\sim 10^{10}\text{ K}$ and thermal x-radiation at 10^7 K . This does not fit the Scorpius source. On the other hand, rapid mass accretion (from a binary companion) onto a white dwarf gives thin-source bremsstrahlung at $\lesssim 10^8\text{ K}$ and a stronger thermal source at $\sim 3 \times 10^5\text{ K}$. Absorption and reradiation by the companion also contribute to visible light. This fits many features of the Scorpius source, including the enhancement of the very soft x radiation.

Photoelectric Photometry of UV Piscium.

ROGER B. CARR, *University of Florida*.—Light curves in the three (U, B, V) colors have been obtained for the eclipsing binary UV Piscium with a 16-in. telescope at the Kitt Peak National Observatory. The 437 individual observations in each color were com-

bined into 68 normal points. The truncated Fourier series representing the normal points outside the eclipses have the coefficients

	A0	A1	A2	B1	B2
V	0.9705	-0.0009	-0.0027	0.0185	-0.0017
	± 0.0007	± 0.0010	± 0.0011	± 0.0008	± 0.0008
B	0.9726	0.0026	-0.0024	0.0199	-0.0020
	± 0.0006	± 0.0009	± 0.0010	± 0.0007	± 0.0007
U	0.9593	0.0126	-0.0077	0.0204	-0.0047
	± 0.0010	± 0.0015	± 0.0017	± 0.0011	± 0.0011

The light curves were rectified with the equations of Russell and Merrill (*Contrib. Princeton Univ. Obs.* No. 26, 1952). An asymmetry represented by the sine term dominates the rectification. No explanation is offered for the failure of the sign of A1 to agree with theory in B and U . A nomographic solution is discussed.

This work has been supported by NSF and NASA.

Variations in the Photometric Properties of RR Lyrae and VZ Cancr with Beat Phase.

C. P. CATALANO AND J. S. NEFF. —The photometric properties of RR Lyrae are compared at two different beat phases. The variations in the photometric properties of VZ Cnc over the entire beat period are discussed.

The values of T_e and $\log g$ at minimum light are derived by comparison with model atmospheres. This method gives values in good agreement with values obtained from scanner observations for RR Lyr and SU Dra, but for VZ Cnc we obtain $T_e = 6900\text{ }^\circ\text{K} \pm 200$ and $\log g = 4.2 \pm 0.5$ to be compared with $T_e = 6200\text{ }^\circ\text{K}$ and $\log g = 2.2$ found by I. J. Danziger and J. B. Oke (*Astrophys. J.* **147**, 151, 1967). Both sets of values have been checked and the reason for the discrepancy has not been discovered.

Critical Considerations on the Theories of Formation of Carbon Cosmic Grains.

FELIX CERNUSCHI AND SAYD CODINA, *Universidad de la Republica, Montevideo, Uruguay*.—Hoyle and Wickramasinghe (*Monthly Notices Roy. Astron. Soc.* **124**, 417, 1962) have proposed a cyclic mechanism for the formation of graphite grains, in the photosphere of class N stars. A more refined calculation on the conditions prevailing in the outer layers of carbon giant stars, by Tsuji (*Ann. Tokyo Obs.* 2nd Ser. **9**, No. 1, 1964), gives a somewhat lower range of temperatures for graphite condensation than that estimated by Hoyle and Wickramasinghe. However, the theory of grain formation in the photospheric envelope of carbon stars is generally accepted as a very plausible one.

We have analyzed critically the following aspects of Hoyle-Wickramasinghe theory:

(1) The carbon partial pressure in the photosphere is overestimated, because their calculation is implicitly based [Hoyle and Wickramasinghe, Eq. (18)] on the assumption of total veiling of radiation by photospheric grains at the lowest temperature of the cycle, which lacks observational basis. The average variation of the apparent magnitude of class N stars catalogued by Kukarkin and Parenago (*General Catalogue of Variable Stars*, Academy of Sciences of the USSR, 1958) does not support in any way the above-mentioned implicit hypothesis. This variation is explained by changes of the surface temperature during the cycle assumed by Hoyle and Wickramasinghe.

(2) A direct estimation of the evaporation rate of the grains, during the first stage of their outward journey, shows that the grains eventually formed in the photosphere are totally evaporated before they can reach an altitude of about 0.2 the star radius.

(3) Hoyle and Wickramasinghe have calculated the total of carbon to the interstellar space supposing that 10^4 class N stars in our Galaxy have been working cyclically, in the same way already mentioned, during 10^9 yr. In that way, they obtained a suitable fit to the average number of cosmic grains per cm^3 . But (even assuming that mixing processes over the entire volume of the star are extremely efficient, which is a very doubtful hypothesis) the admitted rate of carbon supply is so high that every star would have expelled all its carbon atoms in 10^6 yr.

The assumption that graphite is an important constituent of cosmic grains is very plausible, but a theory would be necessary which avoided the contradictions pointed out above. This might be provided by adapting for the formation of carbon grains the theory developed by Cernuschi *et al.* (*Ann. Astrophys.* **28**, 860, 1965).

A Comparison of Photometric Observations with Theoretical Predictions for Rotating Stellar Atmospheres. G. A. CLAPP AND J. S. NEFF, *University of Iowa*.—A preliminary comparison of photometric observations on the Chi system (Neff, J. S., and Travis, L. D., *Astron. J.* **72**, 48, 1967) and β observations with the rotating model atmospheres of Collins and Harrington (Collins, G. W., and Harrington, J. P., *Astrophys. J.* **146**, 152, 1966) is described. A systematic correction of $0^{\text{m}}07$ was applied to the theoretical flux ratios to bring them into agreement with observation. This is within the estimated uncertainty of the absolute calibration. The theoretical β 's were increased by $0^{\text{m}}07$ to bring them into agreement with observation.

Theory and observation were compared on the $\Delta(0.33) - \log[F(0.33)/F(0.55)]$ relation, the $\beta - \Delta(0.33)$ relation, and the $M_v - \Delta(0.33)$ relation. The absolute magnitudes were calculated with trigonometric or cluster parallaxes. It was found that theory and observation were consistent.

For six stars it was possible to estimate V_e and i with large estimated errors, M_v being the most uncertain quantity. The photometric value of $V_e \sin i$ was calculated and compared with the spectroscopic value. The results were consistent within the estimated error although there was a tendency for the photometric values to be 20–50% larger than the observed values.

A more accurate comparison between theory and observation can be made for stars with smaller masses than used above. This is because there are more nearby stars of this type and the photometric effects due to rotation appeared to be larger.

Chromospheric Magnetic Field Changes Associated with Photospheric Motions. ALFRED CLARK, JR., *University of Rochester*.—A theoretical analysis is given of the effect of horizontal photospheric motions on magnetic fields which extend upward into the chromosphere. A method based on "integrals of the motion" allows the calculation of a final static state in terms of an initial static state and the over-all horizontal displacements at the photospheric level. In particular, the method successfully avoids consideration of the dynamics of the transition between the two states; it is restricted to a perfectly conducting fluid, however. Detailed results are presented for the case of small displacements and an initially uniform vertical magnetic field. The dependence of the solution on the initial field strength and atmospheric scale height is investigated. The theory is applied to the problem of the accumulation of magnetic fields by solar supergranulation. The results indicate that the field-channeling role assigned to the supergranulation in current theories of the chromospheric network should be examined more critically.

This work was supported in part by the National Science Foundation (NSF GP 6491).

Spectrum of the Bars in Barred Spirals. ARTHUR D. CODE, *University of Wisconsin*.—In general, the colors of the bars in barred spiral galaxies are similar to the colors of the nuclei. In order to obtain a clearer understanding of the constitution of the bar, slit spectra have been obtained of a number of barred spirals using the Kitt Peak 84-in. reflector. The spectra were obtained using a Carnegie image tube and linear dispersions of 120 or 60 Å/mm. The use of the image tube makes it possible to ob-

tain absorption line spectra of the low surface brightness bars with exposure times of the order of 1 h.

Several important generalizations are possible on the basis of these spectra. First, the absorption line spectra are similar to the spectra of the nuclei suggesting that the main contributor to the light in the bar is from stars similar to those found in the nuclear region. Secondly, the bar usually displays throughout 3727[O II] emission from a relatively uniform distribution of low-density gas. The velocity dispersion of the gas is much smaller than that of the stars. The ionization and excitation of this gas present an interesting problem.

Finally, the differential velocities of the gas emission lines and the stellar absorption lines display significant differences. The gas appears to rotate more like a rigid body while the stellar components show a velocity field similar to that which would be exhibited by a contraction or expansion of the system.

Effect of Axial Rotation upon the Strength of Weak Stellar Lines. GEROME W. COLLINS, II, *Perkins Observatory*.—In this paper we endeavor to estimate the effects of axial rotation upon the formation of weak scattering and absorption lines in the spectrum of a star. Included in the study are some of the processes, resulting from stellar rotation, which influence the equivalent width of the line: shape distortion, gravity darkening, limb darkening, aspect effects, and the variation of the line absorption coefficient over the surface of the star due to varying surface temperature and pressure. In addition, an attempt was made to include effects of the variation of the interior structure with increasing angular velocity.

The atmosphere of the star was approximated by a Milne-Eddington type model with the local value for the effective temperature and surface gravity. An expression for the specific intensity at the surface in both line and continuum was thus obtained from the general solution for the Milne-Eddington model and the resultant profile was numerically integrated over the visible surface of the model.

Results are presented which indicate the variation of weak absorption and scattering lines with changing angular velocity and angle of inclination. It is demonstrated that one of the most important effects governing the strength of the line is the amount of distortion experienced by the star. However, unless the variation of line absorption coefficient with temperature and pressure is extremely large, little change in the equivalent width of the line will be experienced. This leads one to suggest that the variation of the spectral type of a star of given mass is almost totally insensitive to axial

rotation. Since the *UBV* colors are affected by rotation, one would then expect a systematic scatter in the spectral type- $(B-V)_0$ relationship of about 0.04 mag at B3.

Change of Li/Be Ratio in Main Sequence Stars.

PETER S. CONTI, *Lick Observatory*.—A spectroscopic study of the Li and Be content of some bright F and G stars has been completed. The analysis was made with newly measured equivalent widths, a curve of growth, and line strengths predicted from a grid of model atmospheres. The data are combined with previously published results. Under the logical assumption that stars start with a common value for the ratio Li/Be, as evidenced by spallation experiments, it is possible to trace out the pattern of Li destruction.

The change of Li/Be among main sequence stars can be interpreted as an age effect. It is found that the F stars deplete Li on a time scale longer than the age of the Hyades. Since G stars deplete Li on a time scale shorter than this, there must be an inverse relation between the Li destruction rate and spectral type. This is probably related to the deeper convective zone in cooler stars.

The variation in Be abundance of these stars presumably represents a different initial light element content. Several F stars contain no detectable Be (nor Li). Unless they destroyed both elements subsequent to arrival on the main sequence, these stars must have had no initial light-element content.

Abundances Analysis of the A Stars in the

Pleiades. PETER S. CONTI, *Lick Observatory*, AND STEPHEN E. STROM, *Smithsonian Astrophysical Observatory and Harvard College Observatory*.—A model-atmosphere abundance analysis has been made for eight A stars in the Pleiades cluster. The results of this analysis have been compared with those obtained from curve-of-growth techniques, and, with few exceptions, the disagreements are minor. We find that the A stars chosen by Conti (*Astrophys. J.* **142**, 1965) as metallic line A stars on the basis of the Sc II/Sr II line strengths exhibit other abundance anomalies characteristic of this class of stars. The values of microturbulent velocities obtained for these stars are large (in the range 4–6 km/sec), in agreement with previously reported analyses of metallic-line stars. The possibility that the anomalous abundances deduced for these stars are caused by incorrect choice of atmospheric structures was ruled out by computing abundance ratios for a very wide range of atmospheric conditions and finding no conditions that produced normal ratios.

The change of metallicism with depth of convection zone is discussed in view of these results for these stars.

A Cosmic X-Ray Survey from the Southern Hemisphere. B. A. COOKE, K. A. POUNDS, AND E. A. STEWARDSON (introduced by Oscar T. Manley), *University of Leicester*.—A proportional counter spectrometer was flown on an unstabilized Skylark rocket (SL-118) from Woomera, South Australia, on 10 April 1967 with the aim of conducting a search for cosmic sources of x radiation. The flight took place at 20.21 h local time and in the absence of the moon; aspect data are provided by magnetometer and an infrared horizon sensor. The detector area was 300 cm² and a bandwidth of 1.5 to 15 Å was analyzed into six photon energy channels. Improved x-ray sensitivity was provided by inclusion of a recently developed method of pulse noise reduction which exploits the different rise times of the soft x-ray and the "noise" pulses. Spectra are given of the x-ray flux from a number of discrete sources and from the background night sky.

Photographic Search for Comets During 12 November Solar Eclipse. HENRY C. COURTEN AND RICHARD W. GENBERG, *Adelphi University*.—Under NASA grant to Adelphi University a four-man team set up and operated a ground-based photographic station in Bagé in southern Brazil at the centerline of the eclipse path. Specially modified aerial cameras with coverage out to 40 solar radii were used with interference filters and 8×10 in. glass plates to search for small bright comets proximate to the sun.

Although a high thin atmospheric haze resulted in a rather high level of sky background, star images to mag +7 were recorded, along with excellent images of the coronal structure.

The comet search equipment is a follow-on to the initial search conducted by Dr. B. Donn and Dr. Francois Dossin during the 1963 total eclipse. The most recent effort was enhanced by direct cooperation with Wesleyan University (Van Vleck Observatory) which, under NASA grant, supported an airborne observer with identical photographic equipment.

This brief report describes the techniques and equipment used by the Adelphi group. Projection slides exhibit the filter characteristics as matched to the camera lens transmission curve, the equipment erected and ready for field operation, and several sample photographs showing coronal detail. Because of the practical difficulties inherent in reproducing very fine star and comet images arti-

cially enhanced slides of the original negatives are shown.

Complete reduction and analysis of the plates is expected to take several more weeks; therefore conclusions on the existence of the family of comets predicted by Dr. P Swings cannot be drawn at this time. Comparison of very recent star plates with those exposed during the eclipse will be accomplished within the next few weeks. Since the earlier stellar images are too faint for blink comparison the simple, yet effective, techniques which are being employed in the analysis are described.

On the Determination and Astrophysical Application of Oscillator Strengths measured in Free-Burning Arcs. CHARLES COWLEY AND BRIAN WARNER, *Yerkes Observatory*.—We have calculated a model of the emitting regions of the electric arcs used by Corliss and Bozmann (*NBS Mono.* No. 53, 1962) and Corliss and Warner (*Astrophys. J. Suppl.* No. 83, 1964) for the determination of oscillator strengths.

Calculations based on this model show that the normalization function should be very nearly flat for most neutral atoms with ionization potentials less than about 8 eV. For ions and neutral atoms with high ionization potentials, the normalization function should decrease with excitation potential for the higher excitation potentials.

Systematic increases in the excitation temperature of the sun and stars that have been found for the highest excitation potentials may be attributed to systematic errors in the oscillator strengths. These systematic errors were introduced when a universal normalization function was applied to neutral atoms as well as ions.

Intrinsic Colors for Main Sequence A- and F-Type Stars. D. L. CRAWFORD, *Kitt Peak National Observatory* AND BENGT STROMGREN, *Institute for Advanced Study Princeton*.—The four-color data of Stromgren and Perry (*Astrophys. J.*, to be published) and the H β photometry of Crawford *et al.* (*Astron. J.* 71, 1966) have been used to calibrate the intrinsic color $(b-y)_0$ of the *uvby* system in terms of β , Δc_1 , and Δm_1 . The parameter Δc_1 is the difference between the measured c_1 and a zero-age line in a c_1 vs β relation. For A and F stars, it is a measure of relative luminosity for stars of the same temperature. The parameter Δm_1 is the difference between the measured m_1 and the average relation for the Hyades (Crawford and Perry, *Astron. J.* 71, 206, 1966). It is a measure of the relative line blanketing near 4100 Å. Of the 1217 stars in the Stromgren-Perry catalogue, 379 were omitted as being outside

the range of A2 to G0 main sequence stars, and 13 as obviously reddened.

The 825 remaining stars were divided into seven β groups, and a solution of the form $(b-y)_0 = A + B\beta + C\Delta c_1 + D\Delta m_1$ was obtained for each group. For the five groups of earliest spectral type, a mean deviation of $\pm 0^m.011$ (for one star) was found. For the two latest spectral groups it was $\pm 0^m.014$. The coefficients of Δc_1 and Δm_1 are small in all cases, and hence β is a very good predictor of intrinsic color. One can also state that very few of the A and F type main sequence stars brighter than $V=6^m.5$ are reddened by interstellar absorption.

A Search for Extragalactic Radio Sources Having a Flux Excess at Short Wavelengths. MICHAEL M. DAVIS (introduced by T. K. Menon), *National Radio Astronomy Observatory*.—A systematic survey at 1417 MHz (21.2 cm) has covered 3.7 sr of the sky in search of discrete sources missed by surveys at longer wavelengths. The 25-m Dwingeloo telescope has been used with switched beams and a parametric amplifier. The survey is complete to 2.5×10^{-26} W/m²/Hz away from the galactic plane and the North Pole Spur. This limit is set by irregularities in the background radiation. Of 401 sources found in Dwingeloo, 69 have not previously been catalogued. One hundred eighty-eight sources, including all those not previously catalogued, have been reobserved with the Green Bank 300-ft telescope at 20 and 40 cm. A few unusual sources have been singled out for further observations at 2, 6, and 11 cm on the basis of the 20 cm, 40 cm, and when available, longer wavelength flux densities. The source 4C5.64 appears to have a nearly constant flux density over the wavelength range from 2 to 168 cm. The source DW 0202+31 is weaker and hence does not appear in the 4C catalogue; however, over the range 2 to 40 cm, its flux density is also observed to be constant. DW 0742+10 has a flux density maximum near 20 cm. All three sources are unresolved with the NRAO interferometer, implying a size $< 5''$.

Telescope Plus Spectrograph System Optimization. A. H. DELSEMME, *The University of Toledo*.—At the Ritter Astrophysical Research Center of The University of Toledo, we have incorporated our new 41-in. telescope and a high-dispersion stellar spectrograph into an integrated system that is designed to optimize the use of the money available. I. S. Bowen (*Astron. J.* **69**, 816, 1964) has given the efficiency of a telescope as a function of its aperture and of the parameters of the auxiliary instrumentation. However, the question of the optimum price of the auxiliary instrumentation has

so far never received a quantitative answer. This answer is given here in the particular case of a high-dispersion stellar spectrograph by using empirical functions linking the aperture of a telescope and of the collimator of the spectrograph with their prices. For a given grant it is then very easy to maximize the amount of information collected by the system per unit of time. The result is that the prices of the telescope and the spectrograph should be in the inverse ratio of the exponents used in the two empirical price functions. This result is in particular independent of the apertures.

The "best buy" in terms of minimizing the price of each bit of information collected by the integrated system is thus between \$160 000 and \$200 000 for a spectrograph coupled with a 41-in. telescope.

These simple considerations are important, not only for the astronomer who wants to get the best use of his instrument, but for the sponsors who legitimately want the best use of their money.

Hyades Distance Modulus and Stellar Interiors. PIERRE DEMARQUE, *Yerkes Observatory*.—It is shown that Hodge and Wallerstein's recent suggestion (*Publ. Astron. Soc. Pacific* **78**, 411, 1966) of a revision in the Hyades distance modulus does not remove the difficulties previously encountered by Iben (*Astrophys. J.* **138**, 452, 1963) and Bodenheimer (*Astrophys. J.* **142**, 451, 1965) in comparing the Hyades binaries with stellar interior models. The problem seems to lie with the individual parallaxes attributed to each binary system. It is also pointed out that a change in the Hyades distance modulus would not necessarily affect other distances in the universe.

Effects of Stellar Rotation on the Colors and Magnitudes of Stars in Praesepe. R. J. DICKENS, W. KRZEMINSKI, AND R. P. KRAFT, *Mount Wilson and Palomar Observatories*.—Rotational velocities have been determined by J. D. McGee, A. Khogali, W. A. Baum, and R. P. Kraft (*Monthly Notices Roy. Astron. Soc.*, to be published) using an electronographic image tube, and also using conventional spectroscopy, for virtually all the stars in Praesepe brighter than $V=9.6$ mag. New *UBV* photoelectric observations have been made for all the stars for which rotations are available. The photometry is combined with that obtained much earlier by H. L. Johnson (*Astrophys. J.* **116**, 640, 1952). The brighter stars in Praesepe appear to rotate on the average about 15% faster than those in the Hyades at the same absolute magnitude.

Theory indicates that stellar rotation should change the effective temperature, surface gravity,

and absolute magnitude of a star. The effects on the temperature and surface gravity have been investigated in the $U-B/B-V$ diagram. A weak correlation of ultraviolet excess with departure from mean rotation (at a given color) is obtained, although rather less pronounced than that found earlier in the Hyades (Kraft, R., and Wrubel, M., *Astrophys. J.* **142**, 703, 1965).

The effect of rotation on absolute magnitude has been investigated in the color-magnitude diagram, in a manner similar to that followed by P. Strittmatter (*Astrophys. J.* **144**, 430, 1966), who analyzed the same cluster but used less accurate rotations by Tremain and included fewer stars in the analysis. A much weaker correlation of magnitude excess with rotation excess (from the mean at a given color) is found using the new data. This result is more nearly in accord with the smaller effects predicted by models in uniform rotation than those in nonuniform rotation.

Radio Recombination Lines from H II Regions.

JOHN E. DYSON, *Washburn Observatory*.—The temperatures of various H II regions are derived from the total energy in a recombination line of hydrogen and the brightness temperature in the adjacent continuum. The shape of the line is immaterial. The temperatures are compared with those calculated assuming a Gaussian profile. L. Goldberg (*Astrophys. J.* **144**, 1225, 1966) has proposed that partial maser action may occur. The electron temperature may be derived from the total energies in an α and corresponding β transition allowing for this possibility. This method is applied to M17. Inconsistencies in the results are attributed to the complicated nebular structure. The possibility of maser action depends on the variation of b_n and $d \ln b_n / dn$ with n . Values are calculated for these quantities taking into account the local radio frequency radiation field. The results are applied to various observed nebulae.

Near Infrared Measurements of Coronal Polarization in Line and Continuum.

JOHN A. EDDY, JOHN W. FIROR, AND ROBERT H. LEE, *High Altitude Observatory*.—Filtergrams of the solar corona in the near infrared were obtained during the eclipse of 12 November 1966 using an airborne telescope of 8 in. aperture and a two-stage image tube. Interference filters isolated coronal radiation from two spectral regions: a 14 Å band centered on the [Fe XIII] $\lambda 10747$ Å emission line and a 100 Å band of the continuum at $\lambda 10625$ Å. Coronal polarization in line and continuum was measured using a stepped polaroid. Coronal images obtained are of good detail and extend to about 8' above the limb. Ana-

lysis indicates that the emission line polarization varies in amount and direction through the corona but can be described as having electric vector perpendicular to the limb, as expected from resonance polarization theory. Continuum polarization is completely described as having electric vector tangent to the limb. The line polarization measurements extend and confirm the results obtained by Eddy and Malville at the previous eclipse (*Astrophys. J.*, to be published).

Contribution Curves in the Fine Analysis of Stellar Spectral Lines.

FRANK N. EDMONDS, JR., *The University of Texas, Austin*.—Three methods for the fine analysis of spectral lines are: (1) a straightforward combination of formulas arising from pertinent formal solutions to the equation of radiative transfer; (2) the Planckian-gradient method developed by Mugglestone; (3) the weight-saturation method developed by Pecker and others. These three methods are equivalent in that the formulas for one method can be obtained from those of another by simple integration by parts. In each of the three cases the formulas allow the computing of contribution curves which presumably show the relative contribution to line formation of the different layers of the model atmosphere used in the fine analysis.

Computer programs have been developed for the three methods which compute the equivalent width and profiles of spectral lines under the assumption of formation by pure absorption. These programs have been designed to give contribution curves as well. The contribution curves for the same line abundance-model atmosphere situation are quite different for the three methods, and many of the properties of contribution curves which have been determined previously, using the weight saturation method, are not found in those for the formal solution or Planckian-gradient methods. These results lead to the conclusion that contribution curves are critically method dependent and do not provide information about the depth dependence of line formation. Previous determinations of effective depths of line formation based on or related to contribution curves are therefore suspect.

The differences in the contribution curves of the three methods are such that the weight-saturation method weights more heavily the contribution from the upper layers of the atmosphere, while the Planckian-gradient method gives the least weight to these layers. One might expect, therefore, differences in equivalent widths and profiles computed by the different methods because of this difference in weighting. In particular, a method which weighted the most reliably determined layers of a model atmosphere would be preferable. Calculations test-

ing these possibilities are under way, but results obtained so far indicate that differences between the methods are small, except when layer-dependent factors, such as the damping constant, critically affect equivalent widths.

Observations of Planetary Nebulae at $\lambda 3.75$ cm.

JERRY R. EHMAN, *Radio Astronomy Observatory, The University of Michigan*.—Observations of 70 planetary nebulae at a wavelength of 3.75 cm (8000 MHz) with the University of Michigan's 85-ft radio telescope gave values of flux density above $0.1 \times 10^{-26} \text{ W m}^{-2} \text{ Hz}^{-1}$ on 46 nebulae while the remaining 24 were too weak to give useful values. Antenna temperatures of the 46 nebulae ranged from about 0.01° to 0.57°K compared to the rms noise output of the receiver, which ranged between 0.04° and 0.06°K with a 4-sec time constant.

Daily calibrations were made with respect to Cygnus A [with an assumed flux density of $(200 \pm 10) \times 10^{-26} \text{ W m}^{-2} \text{ Hz}^{-1}$] or to other sources whose flux densities relative to Cygnus A are known. Antenna temperatures were corrected for pointing errors, antenna gain variations across the source, and antenna gain variations due to antenna orientation.

Comparison of these observations with published radio and optical observations shows that several nebulae with large radii appear to be optically thick at 8000 MHz.

This research was sponsored by the Office of Naval Research under Contract Nonr-1224(61).

Photoelectric Technique for Detecting Fringes Formed by a Michelson Stellar Interferometer.

JAMES L. ELLIOT, *Harvard College Observatory*, AND FRANK SCHERB, *University of Wisconsin*.—A photoelectric technique for detecting the interference fringes formed by a Michelson stellar interferometer is under development. The technique employs a grid of alternate opaque and transparent bands which moves in the plane in which the fringes are focused. The grid motion converts the spatial variation of light intensity in the fringe pattern to a time variation of the intensity of the light which is transmitted through the grid. The transmitted light is then detected by a photomultiplier.

The signal in the photomultiplier output is related to the visibility of the interference fringes. The fringe visibility can be measured as a function of the separation of the entrance apertures in the Michelson stellar interferometer, and from these measurements angular distributions of the light source can be inferred.

This technique gave good results when employed

to measure the visibility function of a small light source in the laboratory, and is presently being used on bright stars to study the effects of atmospheric disturbances. The results have been encouraging enough to warrant further work which is now in progress at Harvard College Observatory and the University of Wisconsin.

Observations of 3C345, M82 and Other Peculiar Objects with a Scanning Dual-Beam Polarimeter.

AINA ELVIUS, *Astronomical Observatory, Uppsala, Sweden*.—The polarization of light from some quasi-stellar and other peculiar objects has been studied with the scanning polarimeter, constructed by J. S. Hall and described by him in a separate paper. The data were obtained with the 72-in. Perkins reflector of Ohio Wesleyan and the Ohio State University at the Lowell Observatory.

In the observations of starlike objects the scanning served to record the sky background simultaneously with the faint object itself. 3C273, as observed on 9 May, showed no polarization. 3C279 and 3C345 showed variable polarization, as reported by T. D. Kinman (*Astrophys. J.* **148**, L53, 1967).

TABLE I. Observational data for 3C345.

Date (UT) 1967	Filter	P (%)	θ ($^\circ$)	B N (mag)
4 May	BG 12 (+Wr 2B)	3.6	81.4	1 16.4
7 May	None	6.6	75.4	1
7 May	BG 12	5.0	75.0	1 16.4
8 May	None	9.3 ± 0.1	93.9 ± 1.7	2
6 June	None	11.9 ± 0.7	86.1 ± 3.2	2
7 June	None	12.1 ± 1.2	86.3 ± 0.1	2
7 June	UG 1	9.5	92.0	1
8 June	None	8.5 ± 0.4	95.0 ± 0.2	2
9 June	None	8.8 ± 0.9	94.8 ± 0.4	2
9 June	OG 5	10.3	111.6	1
10 June	None	8.2 ± 0.2	93.1 ± 1.8	2
11 June	None	9.3 ± 1.6	99.1 ± 1.6	2

Extended objects were scanned with a slit elongated parallel to a bright filament or dark lane. Tests on the Crab nebula confirmed the observations by Baade and others that the light from its bright filaments is considerably more polarized than the nebulous background.

In the outer parts of M82 individual filaments were scanned in an attempt to discriminate between the polarization due to light from the filament itself and the polarization of the faint luminous background, surrounding the filament. Although the filament showed higher polarization than the background on one side of it, the background light on the other side showed even higher polarization.

Five-Color Photometric Measurements of Near-Earth Satellites. RICHARD H. EMMONS AND RAYMOND J. PRESKI, *Goodyear Aerospace Corporation*.—A comparison of the recent five-color photometric measurements of the Echo I and Pageos I satellites indicates that the near-earth space environment only very slowly degrades the specular reflectance of aluminized Mylar surfaces. The Echo I satellite surface reflectance throughout the *UBVRI* spectral region has changed by less than 2% in its 7-yr orbital history. The *B*–*V* color index values obtained for the Echo I and Pageos I are 0.648 and 0.659, respectively; i.e., each within 0.02 mag of the accepted solar values. The *U*–*V* values were 0.828 and 0.810, which are in excess by more than 10% of the solar value. This is due to non-grey body conditions in the *U*-band region; the normalized *U*–*V* color index is quite close to values obtained by others. Photometric measurements were also performed on the Echo II satellite, and results indicate that this satellite presently has a specular component of reflectance far in excess of conventionally made laboratory measurements. This suggests a possible space environmental effect on the exterior amorphous phosphate coating. Broad-band *UBVRI* plane polarization measurements have also been performed on the three satellites and show that all three satellites tend to follow a theoretical curve for evaporated aluminum.

The NASA Mobile Satellite Photometric Observatory, which has a 24-in., 4 axis-mount telescope, was used for the observations. The broad-band *UBVRI* spectral regions are similar to those of the Lunar and Planetary Laboratory of the University of Arizona; standard stars used for calibration and comparison purposes were taken from catalogues published by this institution. The observations were performed during the summer of 1966 at Palomar Mountain, California, and on the desert floor near Yuma, Arizona, during early 1967. Results obtained from this series of observations have shown that useful information on the effect of the space environment on various types of materials and/or coatings can be reliably and accurately determined with the use of passive ground-based techniques.

This research was conducted with the financial support of the NASA-Langley Research Center.

Star Sightings from Manned Spacecraft. D. C. EVANS AND L. DUNKELMAN, *Goddard Space Flight Center*.—Mercury and Gemini astronauts have reported on the difficulties of seeing stars in the daytime. There have been a few examples of daytime star sightings. E. P. Ney and W. F. Huch (*Science* **153**, 297, 1966) analyzed the circumstances under which their zodiacal light photography experi-

ment was conducted on Gemini V, and determined that first- and second-magnitude stars were seen during daytime. We have recently analyzed star sightings by the Gemini VI crew (Stafford, T. P., Schirra, W. M., and Grim, D. F., Mid-Gemini Program Conference, pp. 283–279, NASA SP-121, 1966; Roach, F. E., Dunkelman, L., Gill, J. R., and Mercer, R. D., *ibid.*, pp. 115–323) during their acquisition and rendezvous with Gemini VII. From Gemini VI, stars as faint as 4.5 mag were observed by day.

We feel that the difficulties frequently experienced by astronauts in seeing stars from orbit can be completely explained by physiological optics, glare on the window surfaces, and ambient light level in the cockpit. It is not necessary to introduce a spacecraft corona (Newkirk, G., *Planetary Space Sci.*, to be published) as far as star sightings are concerned. A table of the circumstances of day and night star sightings from Gemini VI as a function of solar position and time for dark adaptation is discussed.

Solar Granules in the Ultraviolet and Yellow.

JOHN W. EVANS, *Sacramento Peak Observatory*.—Studies of rms vertical velocities in the solar atmosphere, evidenced by local Doppler shifts in Fraunhofer lines, show a marked dependence on both line strength and the wavelength region. The rms velocities increase towards the ultraviolet, and with increasing line strength (i.e., with height in the solar atmosphere). This is a report of an investigation to determine whether the detail of photospheric granular structure also varies between widely separated wavelength regions.

The observational material consists of four pairs of spectrograms showing good spatial resolution along the slit. Each pair consists of a short length of the spectrum centered at $\lambda 3954$ (*UV*) and another at $\lambda 5888$ (*Y*) exposed simultaneously. The spectrograph slit was carefully oriented perpendicular to the horizon, parallel to the small displacements caused by differential atmospheric refraction. Each *UV* frame was traced perpendicular to dispersion by a digital microdensitometer at five continuum wavelengths, and each *Y* frame at three wavelengths.

The cross correlations between the four pairs are 0.85 ± 0.02 , and we conclude that the granular structure at $\lambda 3954$ is very nearly identical with that at $\lambda 5888$. This result directly contradicts that found by Vassiljeva (*Solar Phys.* **1**, 16, 1966) from photoelectric scanning across the solar disk with a sensitive spot 0".2 in diameter. She found that the correlation rapidly decreased with wavelength difference, and had a value of only about 0.1 for a span of 1900 Å. The Sacramento Peak spectrograms

showed a relative displacement along the slit of $2''.1$ between the *UV* and *Y* images due to atmospheric refractive dispersion. I suggest that the low correlations between the structures Vassiljeva recorded at widely different wavelengths are the result of the atmospheric dispersion. This would cause her $0''.2$ sensitive spot to scan along parallel lines in different colors, the separation of which would increase with wavelength difference, and inclination to the vertical circle.

A Model Coronal Active Region Derived from Recent X-Ray Measurements. K. EVANS AND K. A. POUNDS, *University of Leicester*.—Two plane crystal Bragg-type spectrometers were successfully flown on a sun-pointed Skylark rocket on 5 May 1966, obtaining four separate spectral scans in the wavelength band 11 to 25 Å. A previous list of the identified emission lines has already been published (Evans, K., Pounds, K. A., and Culhane, J. L., *Nature* **214** 41, 1967). In the present paper, a more complete analysis is reported, including the absolute flux values in each line. The emission components in each line arising from the dominant active region on the sun on the day of the flight are resolved and thus a model for the particular coronal active region is derived. This model is compared with concurrent radio and optical observations. Previously reported solar abundances of neon, iron, nickel, and oxygen are compared with values derived from the present results.

Relative Abundances of C, N, O, and Ne. C. Y. FAN, G. GLOECKLER, AND J. A. SIMPSON, *University of Chicago*.—Our experiment on the IMP-III satellite has a mass resolution which makes it possible to determine unambiguously the charge of a cosmic ray nucleus in the charge range $1 \leq Z \leq 12$ and its energy in the range ~ 40 to 200 MeV per nucleon. The abundance ratios relative to oxygen for C, N, and Ne are 0.93, 0.23, and 0.16, respectively. For fluorine, the ratio is $< 10^{-3}$. The consequences of these measurements for propagation in interstellar space and the origin of cosmic rays are discussed.

One Micron Spectra of Several Carbon Stars. THEODORE D. FAY AND THOMAS MORGAN, *Indiana University*.—The spectra of the carbon stars RY Dra and Y CVn have been photographed from 9800–10 800 Å, using infrared image intensifiers at a reciprocal dispersion of 40 Å/mm. We have measured the spectra on a Grant engine, recording plate density along the spectrum as a function of screw reading. The screw readings were converted to wavelengths from the standard wavelengths of a

Ne–Ar arc. Dr. Wyller has given us calibrated *I-Z* plates of Y CVn to check the above method.

To aid in the interpretation of these observations, we have computed synthetic carbon star spectra. Our program uses a simple isothermal slab model to compute the spectrum from a given relation between opacity and wavelength. The opacity is computed by adding the components due to all the lines of the ^{12}C and ^{13}C isotopes of the CN and C_2 radicals that occur within a small chosen wavelength interval (about 0.5 Å). The program gives a Gaussian profile to each line to account for the instrumental broadening. The wavelengths of molecular lines computed from the formula are: the (1,0), (2,1) and (3,2) bands of the red system of CN, and the (1,0) and (2,1) bands of the red system of C_2 .

Our program can vary the $^{12}\text{C}/^{13}\text{C}$ ratio, the CN/ C_2 ratio and the radial velocity to maximize the correlation between the computed and the observed spectra, in a 50 to 100 Å band. We find a correlation of about 0.4 for a pure CN model and about 0.3 for a pure C_2 model, per 100 observed points, although these correlations will depend somewhat on the regions of the spectrum considered. Typical correlations for a CN plus C_2 model are from 0.65 to 0.70. The correlation drops sharply if the radial velocity is changed from the optimum value. Our estimate of the $^{12}\text{C}/^{13}\text{C}$ ratio, 3.0 ± 1.0 , agrees with Wyller's estimate in Y CVn. The optimum CN/ C_2 ratio is 4.0 ± 1.0 , but the electronic *f* values are uncertain.

Possible sources of error and applications of this correlation are discussed.

Radiation and Physical Properties of the M87 Jet. JAMES E. FELTEN, *University of California, San Diego*.—Existing observations of the jet in radio galaxy M87 are reviewed and compared with the consequences of various theories as to its physical structure. Many observational uncertainties remain, even in the optical band. If the optical electrons are produced at the nucleus and escape outward to the end of the jet, the ambient plasma must also move outward with mass velocity $\sim c$; streaming instabilities and the short lifetimes of the fast electrons preclude the possibility that they move in a stationary plasma.

Production of secondary electrons by a large proton flux provides a tenable model; the age of such a jet is $\sim 10^5$ yr, and a plasma density $\sim 200 \text{ cm}^{-3}$ is sufficient to maintain it this long against the internal cosmic-ray pressure. The equipartition field is $\sim 10^{-2}$ G. This model will be in conflict with Čerenkov-shower upper limits if the recently observed x rays are shown to be synchrotron radiation.

Local acceleration of optical electrons by plasma processes in the jet remains a strong possibility. Fermi statistical acceleration, however, is not promising; it is augmented by turbulence but still requires random velocities $\gtrsim 3000$ km/sec and fields $\lesssim 3 \times 10^{-6}$ G. Adequate theories of plasma acceleration are lacking.

If x-ray electrons are produced as secondaries or accelerated locally over much of the lifetime of a radio galaxy, the diffuse x-ray background may be due to such sources. They should also produce optical synchrotron radiation.

A Search for Point Sources of Gamma Rays with a Digitized Spark Chamber. C. E. FICHEL, T. L. CLINE, C. H. EHLMANN, D. A. KNIFFEN, AND R. W. ROSS, *NASA/Goddard Space Flight Center*.—A series of high-altitude balloon flights have been made in the northern and southern hemispheres beginning in September 1966 to look for possible point sources of gamma radiation above 30 MeV. The heart of the detector system that was used in these investigations consisted of a 32-level magnetic-core digitized spark chamber with thin (1/50 radiation length) high-Z pair-producing plates between each spark module level. This spark chamber unit is surrounded by a bell-shaped plastic scintillator dome and is triggered by a coincidence between a central scintillator and a Čerenkov counter together with an anticoincidence of the dome. This device is flown in a balloon gondola that is oriented by means of a gas jet system that in turn is controlled by information from a magnetometer. Data related to Scorpius X-1, the galactic center, the Kepler supernovae, the Sagittarius x-ray sources, and Centaurus A in the southern hemisphere and Taurus A in the northern hemisphere are presented. At the present time, upper limits for γ rays above 30 MeV of 3×10^{-5} (cm² sec)⁻¹ have been established for Scorpius X-1, the galactic center, the Kepler supernovae, Oph XR-1, and Sgr XR-2. Other and more complete data on possible point sources are presented, and there is a general discussion of the energy spectrum of the secondary γ rays.

The Region of Formation of the Metallic Emission Lines of AG Pegasi. M. FRIEDJUNG, *Queen's University, Kingston*.—A photometric study of the intensities of the spectrum lines of the symbiotic star AG Pegasi is in progress. A study of the metallic emission lines by a curve of growth technique has given excitation temperature values dependent on excitation potential, and of the order of several thousand degrees. A lower limit to the size of the emitting region in 1946 can also be set from this investigation, and is around 10^{12} cm. This can be

combined with other data to deduce that if the star is binary, the metallic lines are formed far from the blue component, but on the same side of the system.

Multiple Periodicities of the Delta Scuti Stars. WAYNE FULLERTON, *University of Kansas*.—The light curves of all the well-observed δ Scuti stars and of several new δ Scuti type stars have been analyzed for multiple periodicities. δ Del, CC And, and δ Sct are remarkably similar to one another. These three stars exhibit a secondary frequency approximately 1 rad/day from the primary and they show close frequency pairs on the order of 0.2 rad/day apart. DQ Cephei and ρ Puppis do not show close frequency pairs or a secondary frequency near the primary, although it may be that such frequencies have an amplitude too small to be detected. The new δ Scuti stars (ϵ Cep, 4 CVn, HR 812, and β Cas) exhibit frequencies that correspond to those present in DQ Cep and ρ Pup. The frequencies present in terms of the primary, ω_1 , are $\omega_2 = 0.269 \omega_1$, $\omega_3 = 0.640 \omega_1$, $\omega_4 = 1.30 \omega_1$, $\omega_5 = 1.66 \omega_1$, $\omega_6 = 1.89 \omega_1$, and $\omega_7 = 1.99 \omega_1$. Thus approximate relationships among the secondary frequencies may be derived:

$$\begin{aligned} \omega_6 &= \omega_3 + \omega_4 = \omega_2 + \omega_5 = 3\omega_3, & \omega_6 &= \omega_1 + \omega_3, \\ \omega_4 &= \omega_1 + \omega_2 = 2\omega_3, & \omega_7 &= 2\omega_1. \end{aligned}$$

These frequencies are very nearly, if not exactly, those present in dwarf Cepheids.

The secondary frequencies close to the primary might be due to differing polar and equatorial radii just as may be the case for β CMa stars. The method of Böhm-Vitense can be used to derive an entirely reasonable rotational velocity of 75 km/sec, which compares favorably with 85 km/sec, the mean value for stars of similar spectral and luminosity classes. The close frequency pairs may be due to tidal effects from a binary companion. δ Del has been reported to be a double-lined spectroscopic binary of high eccentricity with a period on the order of 40 days. The beat frequencies caused by the two pairs of close frequencies are just one and four times a frequency corresponding to a period of 55 days. If this explanation of the close frequency pairs is correct, then we should expect that CC And and δ Sct and perhaps others are also binaries.

Some Characteristics of the Association III Cephei. R. F. GARRISON, *Mount Wilson and Palomar Observatories*.—III Cephei is one of the youngest of the associations within 1 kpc. It is only 2° from the plane of the Milky Way, has no central cluster, and contains a considerable amount of dust. This

association is considered to be one of the best cases for a high ratio of total to selective absorption.

Accurate spectral classifications from McDonald spectrograms are presented for 73 of the stars listed by Blaauw, Hiltner, and Johnson (*Astrophys. J.* **130**, 69, 1959). There is considerable scatter in the H-R diagrams, both for $R=5.4$ and for $R=3$. However, the results clearly indicate that the ratio $A/E_{B-V}=3$ is suitable for the O-B5 stars, and that the suggestion of a higher ratio was influenced by the inclusion of a number of foreground stars later than B6.

Photoelectric Photometry of H II Regions.

WILLIAM L. GEBEL, *Washburn Observatory*.—A program for photoelectric determination of total $H\alpha$ and $H\beta$ fluxes of diffuse nebulae is under way. The measurements are made with a 2-in $f/3.8$ achromat through interference filters of width 10 Å mounted in parallel light. From radio continuum fluxes the total absorption is derived using the theory of recombination. The reddening is taken from the measured Balmer decrement and from color excesses of associated stars. The result will be a new test of the law of interstellar reddening: the ratio of total to selective absorption, $R=3$.

The Balmer fluxes of 15 nebulae have been determined and new 6-cm radio fluxes for 10 nebulae have been measured with the 140-ft NRAO telescope.

Airborne Eclipse Comet Search and Related Experiments. JAMES GIBSON, *Van Vleck Observatory*.—During the solar eclipse of November 12, 1966 three modified K37 aerial cameras were operated aboard a four-engined jet aircraft to back up the ground-based comet search described elsewhere (Courten, H. C., and Genberg, R. W., *Astron. J.* **72**, 791, 1967, this issue). The cameras were rigidly attached to the aircraft, with no means of guidance to offset angular motions of the aircraft, and with no protection from vibration. Eastman Kodak type 2475 emulsion on 9½-in.-wide Estar base was conformed under vacuum to the curved field of the camera objectives. The longest exposures were 1 sec in white light (3900–7000 Å).

The NC-135 aircraft, operated by the U. S. Air Force for the Atomic Energy Commission's Lawrence Radiation Laboratory, was flown for 200 sec in the moon's shadow. In all, 110 exposures were made. No comets were observed. The limiting magnitude in eclipse was about 2.5. Camera focus settings were slightly inaccurate because persistent cloudy weather and camera trouble during the preparation period prevented final focus adjustments until after the eclipse. In addition, coronal

light scattered by the clear atmosphere above the right altitude of 34 000 ft provided an intense sky background. Well-focused star images fainter than fifth magnitude would have been difficult to detect against that background.

On two subsequent night flights, star fields were photographed with a well-focused camera, with exposures as above. Preliminary evaluation shows that images of stars to a V magnitude of 6.5 or fainter appear on 10% of these 1-sec exposures. They are sharp, or only slightly tailed by rolling of the aircraft during part of the exposure. On another 40% of the exposures the images have somewhat longer tails, but they still reach mag 6.0 to 6.4.

These results indicate the usefulness of this experimental technique for certain observational problems. For the airborne comet search in eclipse, longer-focus cameras with the same 12-cm aperture should be used, with shorter exposures on the same emulsion. This will decrease the limiting magnitude, but the sky background, which limited this attempt, will decrease more rapidly. The best compromise may take a focal length about 50% greater than that used, with exposures of $\frac{2}{3}$ sec.

Support of these experiments by the National Aeronautics and Space Administration (Grant NASA NGR-07-006-003), and the Atomic Energy Commission (window space on the aircraft, camera mountings), is gratefully acknowledged. Without the assistance of numerous individuals at NASA Goddard Space Flight Center and Ames Research Center, Lawrence Radiation Laboratory, Edgerton, Germeshausen, and Grier, Inc., and Kirtland Air Force Base, these experiments could not have been carried out.

Spectrum of VV Cep in the Photographic Infrared.

R. GLEBOCKI AND P. C. KEENAN, *Perkins Observatory*.—Measurements of radial velocities and equivalent widths were made for some Fe and Ti lines, calcium triplet, and two O I blends, on spectrograms obtained at Perkins Observatory during the period from September 1943 to December 1964. Dispersion of the spectrograms was about 45 Å/mm.

Our radial velocities when superposed on Peery's plot (*Astrophys. J.* **144**, 672, 1966), seem to fit his data quite well.

Intensities of Ti and Fe lines did not change during the entire period while weakening of the three lines of calcium was observed in 1947 and probably in 1964–1965. But the most noteworthy event in photographic infrared region was the transient appearance of the blended lines of O I at $\lambda 7774$ and 8446 Å. The lines were observed in 1944–1945 and 1964–1965. Their intensity was high, comparable to the strength of these lines in B, A, F, supergiants.

The strength of $\lambda 8446$ blend relative to $\lambda 7774$ suggests that there is probably no Lyman- β emission in the region occupied by oxygen atoms. Although exact times of appearance and disappearance of O I blends was impossible to determine from our limited observations, it appears that both apparitions coincide with predicted times of secondary minimum. It is likely that they arise from a cloud of oxygen gas, probably surrounding the early-type component, which produces absorption when in front of the larger M-type component.

Measurements of radial velocities for these blended O I lines were difficult because of small dispersion and their composite nature, but in the most cases our spectrograms do not indicate strong stream motions for the oxygen atoms. Only in October-November 1944 was there evidence of oxygen outflow at 15 to 20 km/sec.

Population of Atomic Levels by Dielectronic Recombination. LEO GOLDBERG AND ANDREA K. DUPREE, *Harvard College Observatory*.—Under conditions found in H II regions, the populations of excited levels of atoms are determined primarily by the balance between electronic recombination and cascade into the levels and spontaneous transitions out of them. The bare nucleus of a hydrogenic ion can combine only by radiative capture but an ion that has one or more electrons can capture an electron by dielectronic recombination. This process may occur at a much faster rate and with a wholly different dependence on n and l than that of radiative capture. Illustrative calculations have been performed for Ca I in which the levels are assumed to be populated by dielectronic and three-body recombination and cascade, and to be depopulated by spontaneous downward transitions and collisional ionization.

The results show that (1) the capture of electrons by dielectronic recombination can greatly increase the populations of highly excited levels as compared with their equilibrium values; (2) there will be a value of the total quantum number n for which b_n , the ratio of the actual population to that in thermodynamic equilibrium, has a maximum value. This maximum occurs at $n \sim 50$ to 100 for $N_e = 10^4 \text{ cm}^{-3}$ and at $n \sim 100$ to 200 for $N_e = 10^2 \text{ cm}^{-3}$; (3) recombination lines from complex atoms should be found in emission and, with the appropriate conditions, in absorption.

A Stochastic Theory for the Wavelength Dependence of Linear Polarization of Radio Sources. SAMUEL J. GOLDSTEIN, JR., *Leander McCormick Observatory*.—The following model is proposed: The source contains n elementary radiators or cells of

equal power output which have perfect linear polarization independent of frequency. Some cells m have identical polarization angles, while the remaining $n-m$ cells have polarization angles which are independent random variables with a uniform probability density function over the range 0 to 2π . Between each cell and the observer is a medium which produces Faraday rotation of the polarization angles. The Faraday rotations are independent Gaussian random variables with a standard deviation of $R \text{ rad/m}^2$. The fractional polarization is the expected value of the sum of the polarization vectors divided by n , and is given by the formula

$$u(\lambda) = [(2n)^{-1} + m(m-1)n^{-2} \exp(-R^2\lambda^4)]^{\frac{1}{2}},$$

where λ is the wavelength in meters.

The model fits the observations of many radio galaxies and quasi-stellar sources including 3C33, MSH 23-64, 3C196, and Her A; but it fails to fit the observations of Cyg A and Tau A. The source Cyg A has an increase in fractional polarization with wavelength near 1 cm, but the model can give only constant or decreasing fractional polarization with wavelength. Extensions of the model which could describe Cyg A and Tau A seem feasible. The average rotation measure of the source (a measurable quantity) is independent of the fractional polarization in the present theory.

Burn and Sciamma (*Monthly Notices Roy. Astron. Soc.* **133**, 5, 1966) have described a theory based on a Fourier transform relation between the fractional polarization and a function which distributes the radiated power with Faraday depth. (At a certain Faraday depth, the number of rotations to the observer is constant.) The Burn and Sciamma theory requires that the average polarization angle of each Faraday depth is identical, but no such assumption is required in the present theory.

Convection in Pulsating Stars: Time-Dependent Mixing-Length Theory in the One-Zone Model. D. O. GOUGH, *Joint Institute for Laboratory Astrophysics*.—By considering in detail the motions of convective elements, Vitense's mixing-length theory of turbulent convection has been reformulated so that it can be used in stellar envelopes whose ensemble mean properties are time dependent. To determine in which regions of the H-R diagram radially pulsating stars lie, it is usual to perform a linear stability analysis of static models. The time dependence of the perturbations is exponential; the equation of motion of the convective elements can then be integrated analytically, and explicit expressions for the variations in convective heat flux and turbulent pressure can be obtained.

To gain insight into how convection can affect the stability of a star, the revised mixing-length

theory has been applied to Baker's one-zone model [*Stellar Evolution* (Plenum Press, New York, 1966), p. 333] to estimate how the convection varies as the star pulsates. In general, the convective heat flux increases as the star compresses and so exerts a stabilizing influence. Furthermore, because the variations in the convective velocities are not in phase with the pulsation, the turbulent pressure can do work on, or be worked on by the star, and so influence the growth or decay of the pulsations. When the characteristic time scale of the convection is very much greater than the pulsation period, the effect is stabilizing, but when the convection time scale is short, the converse is true.

Although no definite conclusions concerning the stability of a star can be drawn from the one-zone model, it does seem likely that convection tends to stabilize stars at the right-hand edge of the Cepheid instability strip, bringing theoretical predictions into closer agreement with the observations, and also provides an important destabilizing mechanism in the long-period variables.

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Integrated Colors and Magnitudes of Open Clusters. DAVID F. GRAY, *University of Western Ontario*.—Integrated colors and magnitudes may be the only observable characteristics of some stellar systems. As a convenient standard of reference we can use the integrated colors and magnitudes of open clusters in the galaxy which are easily found by summing the luminosities of the individual stars comprising the cluster.

The integrated colors and magnitudes of open clusters have been shown to be correlated along a line interpreted as an aging trajectory (Gray, D. F., *Astron. J.* **70**, 362, 1965). In the present investigation artificial cluster evolution is investigated numerically to see if in fact any given cluster moves parallel to the observed correlation. This pseudoevolution is accomplished by subtracting, sequentially in order of brightness, the flux of each star from the cluster total. The giant stage of the star's life is neglected.

In the majority of cases the cluster does follow the expected trajectory. It is also found that the computed tracks depend only slightly on the cluster's luminosity function.

Each computed track must eventually end up on the stellar main sequence if the faintest stars left in the cluster are main sequence objects. After evolving parallel to the observed correlation, the cluster usually drops steeply onto the stellar main sequence. This is particularly noticeable in the $U-B$

plane where the characteristic wiggle of the stellar main sequence holds the color between 0.0 and 0.10 for a three-magnitude range in M_V .

Models of Interstellar Grains. J. MAYO GREENBERG, *Rensselaer Polytechnic Institute*.—A detailed analysis is made of several criteria for distinguishing between various interstellar grain models. The observations of extinction in the ultraviolet out to $\lambda^{-1} \approx 8 \mu^{-1}$ lead to interpretive difficulties for all presently well-studied grain models—dielectric spheres, core-mantle (mostly spherical), and dielectric cylinders. If "normal extinction" is required to be satisfied in the range $1 \leq \lambda^{-1} \leq 3 \mu^{-1}$ then the calculated extinction for the above models does not rise as much as required by stated observational results at $\lambda^{-1} \approx 8 \mu^{-1}$. Up to $\lambda^{-1} = 5 \mu^{-1}$ the latter two models are reasonably satisfactory. Anomalous extinction curves in the far infrared as reported by Johnson are equally difficult to satisfy by the three general models if one assumes normal extinction in the visible. The anomalous extinction can be most easily accounted for by locally *very* anomalous grains.

The orientation by magnetic fields and subsequent polarization are more easily satisfied by elongated dielectric than by spheroidal core-ice mantle particles.

Excitation of Interstellar OH by Plasma Shielding Currents. HOWARD D. GREYBER, *Martin Company*.—A new mechanism for the excitation of the interstellar OH (hydroxyl) radical is proposed that apparently explains many of the very puzzling features of the interstellar OH radio emission. The mechanism invokes the Debye shielding current that must be present when a plasma expands against a magnetic field (or vice versa). Such a current would arise, for instance, at the border of a hot nebula which is expanding against the general spiral arm magnetic field, such as IC 1793 (W3) and NGC 6334.

Because of the characteristic resonance denominators in the usual calculation of quantum-mechanical transition probabilities, the excitations (and therefore line strengths) depend *critically* on the values of the *local* velocities, conductivities and magnetic fields. Thus the model explains qualitatively the compactness of the OH emission sources, the great departure from expected line-intensity ratios and the presence of OH emission at the edges of the ionized hydrogen regions.

Because of the high conductivity and consequent "snowplow" nature of the plasma-magnetic field interaction, the magnetic field will be strongly amplified *locally* at the edge of the expanding nebula